Control Schemes for Small Distributed Energy Resources

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Control Schemes for Small Distributed Energy Resources

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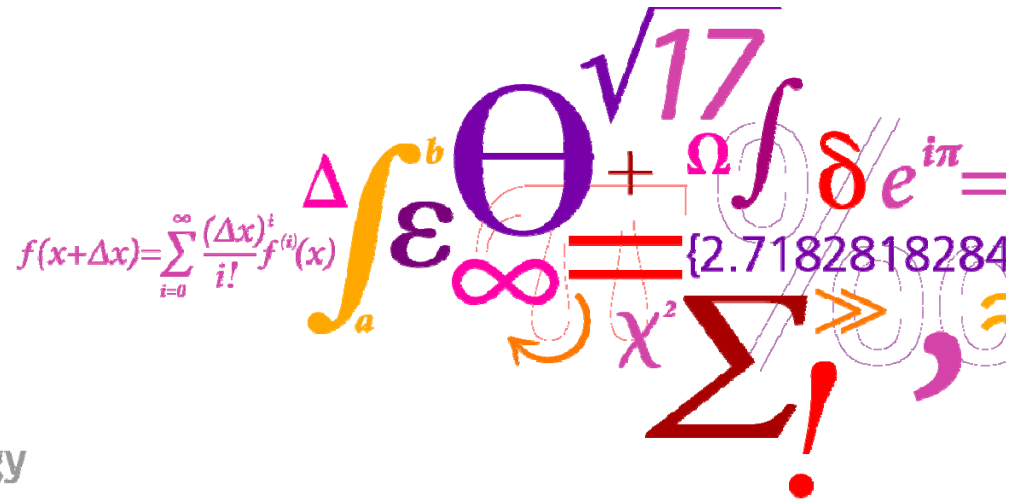


Risø DTU
National Laboratory for Sustainable Energy

Presentation Outline

- Background/Introduction
- Functions to be provided by small DER
- Issues/Requirements
- Examples

- Summary and conclusion

Background

- Increased amounts of WE
- Increased need for regulating capacity and reserves on different time scales
- Desire to decrease dependence on large central power plants for system services
- Consumption side has a potential for participation since part of the load can be deferred
- More sources of ancillary services
  - Many TSO's are including consumption side
  - Requirements for large contributions
- (substitute fossile fuels in heating and transport thus linking other energy subsystems)

What is it we want

- We want to utilize the potential resources already present in the system
- We want a cheap system since the individual contributions are small
- Flexible:
  - Ability to fine tune function
  - Change behaviour depending on context
  - Implement several functions
- Scalable
- Automatic
  - Little or no user intervention required during setup and operation
- User and system interests/needs/requirements
- Deterministic behaviour/predictable

Classes of functions

- System supporting functions – ancillary services
- System operation optimisation
  - Peak shaving
  - Economic optimisation/trading
    - Shifting loads to low load situations
  - Wind power coordination

Ancillary Service Description

- **Continuous Regulation**
  - Provided by online resources with automatic controls that respond rapidly to operator requests for up and down movements. Used to track and correct minute-to-minute fluctuations in system load and generator output.
- **Energy Imbalance Management**
  - Serves as a bridge between the regulation service and the hourly or halfhourly bid-in energy schedules; similar to but slower than Continuous Regulation. Also serves a financial (settlement) function in clearing spot markets.
- **Instantaneous Contingency Reserves**
  - Provided by online resources equipped with frequency or other controls that can rapidly increase output or decrease consumption in response to a major disturbance or other contingency event.
- **Replacement Reserves**
  - Provided by resources with a slower response time that can be called upon to replace or supplement the Instantaneous Contingency Reserve in restoring system stability.
- **Voltage Control**
  - The injection or absorption of reactive power to maintain transmissionsystem voltages within required ranges
- **Black Start**
  - Generation able to start itself without support from the grid and with sufficient real and reactive capability and control to be useful in system restoration.

From: G. Heffner et al: Loads Providing Ancillary Services: Review of International Experience, LBNL-62701

What are the issues

- How can millions of units be handled in a coordinated way
- How is flexibility obtained
- How can it be cheap
  - Communication
  - Computing requirements
- Reliability
- Topology/grid limitations/control areas
  - Local vs. Global issues

Tariffs – fixed or dynamic schedule

- Very simple to implement
- User can be in control, and is often in the loop
- It can be automated
- Current situation of grid is not taken into account (only predicted situation when prices were settled)
- If prices are updated often, behaviour will approach real time price systems

- Aggregation
  - Not needed
- Control signal
  - Price schedule/time
- Communication
  - Needed, oneway
- Flexibility
  - Limited, often User dependent
- Scalability
  - Good
- Cost
  - Low

Frequency based load shedding

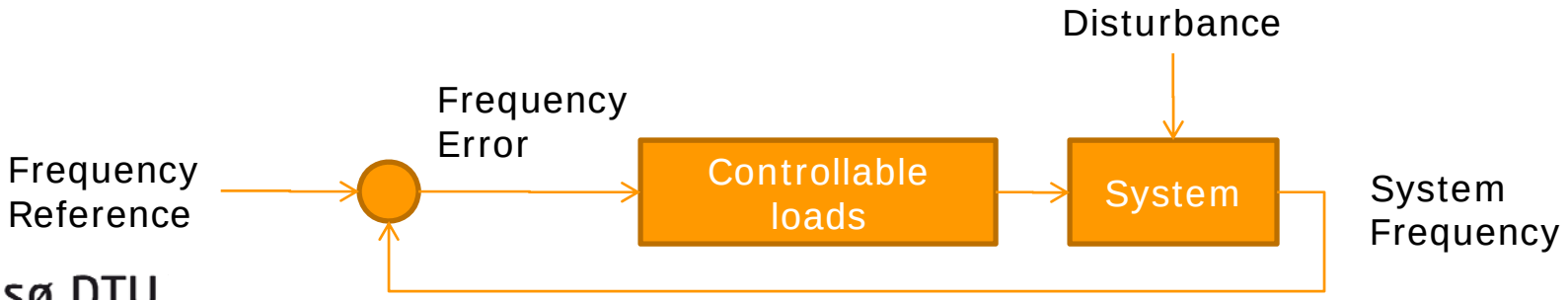
- Disconnection of load in extreme situations
  - Frequency based
  - Both under- and over-frequency
- Implementation is simple
- Only active in contingency situations
- Reconnection and synchronisation of state can be an issue
- Amount that is being disconnected cannot be directly controlled
- Very short response time

- Aggregation
  - Not needed
- Control signal
  - frequency
- Communication
  - Not needed
- Flexibility
  - Pre-programmed
- Scalability
  - good
- Cost
  - low

Frequency control

- Normal operation mode i.e. load has to be served, but can be deferred
- System frequency is available and easy to measure
- Can be implemented without communication, but is then inflexible
- Local bottlenecks cannot be handled without communication
- Fast response time

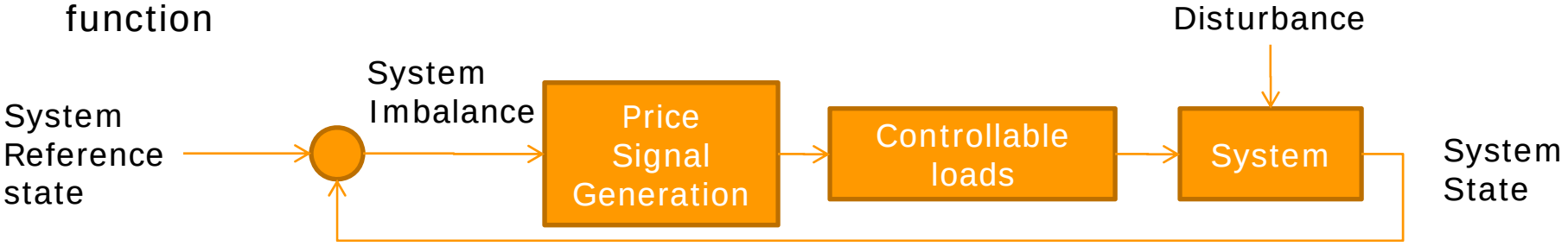
- Aggregation
  - Needed if flexible
- Control signal
  - frequency
- Communication
  - Not needed, but then inflexible
- Flexibility
  - Limited
- Scalability
  - Implementation dependent
- Cost
  - Implementation dependent



Real Time Price Signals

- Needs transparent mechanism for price generation
- Requires broadcast of price signal
- Bottlenecks implies different prices for different areas
- How real time is real time
- Will the system be stable/what other functions are required
- Will all loads participate
- The price curve can be non-linear
- The TSO will not know the behaviour due to price changes
- The user determines the price function

- Aggregation
  - Not needed (at loads)
- Control signal
  - price
- Communication
  - Needed, price broadcast
- Flexibility
  - User determines cost function
- Scalability
  - good
- Cost
  - low



Virtual Appliances

- Aggregation of similar entities
- Aggregator controls switching directly
- Using bidirectional communication load shapes can be constructed
- Can pre-charge unit for improved/increased behaviour at later time
- For scalability only few hundred are grouped
- More aggregation layers are required
- More advanced curve shapes can be implemented
- Short response time

- Aggregation
  - Needed
- Control signal
  - Switching commands/time to switch
- Communication
  - Needed, uni/bidirectional
- Flexibility
  - Various load shapes can be implemented
- Scalability
  - Good?
- Cost
  - Low?

Summary

	Tariffs	Load-shedding	Frequency control	Real time price signals	Virtual Appliances
Aggregation	Not needed	Not needed	Not needed	Not needed	Needed
Control signal	Schedule	Frequency	Frequency	Price	Switching commands
Communication	Unidirectional	Not needed	Not needed	Needed, price broadcast	Needed, uni/bidirectional
Flexibility	Limited, often user dependent	Pre-programmed	Limited	User determines cost function	Various load shapes can be implemented
Scalability	Good	Good	Implementation dependent	Good	Good?
Cost	Low	Low	Low	Low	Low?

Conclusion

- TSO's are willing to include consumption side as a source of ancillary services
- Challenge is to include small resources connected at the low voltage network in the control of the system
- Most schemes are only implementing one function and are therefore not fully exploiting the potential
- Relies on communication is available or is pre-programmed and inflexible
- There is room for implementation of more complex and flexible behaviour -> Policy-based control

Thank you